



Markets for Cleaner Air: Cap & Trade Simulation

Participant's Guide

About this Guide and the Simulation

Simulation purpose

The purpose of the Cap & Trade Simulation (“the simulation”) is to allow you to put the theory of cap and trade into practice. The facilitator will assign you an electric generating facility for which you must develop compliance strategies to achieve an emission target.

Organization

This *Participant's Guide* walks you through the basic rules and functionality of the simulation. This guide includes “tips” that may help you understand how to make decisions when managing your simulated power plant. Tips are identified with a light bulb icon.



This “Tip” symbol indicates that additional insight or knowledge is available for you.

Simulation system requirements

- Windows XP, Vista, or Windows 7; and
- Microsoft .Net 3.5 or greater.

Licensing and contact information

The simulation and its documentation were developed by the United States Environmental Protection Agency (EPA) to educate participants about the cap-and-trade policy approach. The software and documentation are available upon request at no cost. If you have questions or wish to request the most recent version of the software, please contact:

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Introduction to Emission Trading

Cap-and-trade programs can be a very cost-effective policy approach to achieve broad, regional emission reductions. A cap-and-trade program establishes a cap, or maximum limit, on total emissions from a sector or group of emission sources. The cap is allocated to the sources in the form of allowances. Each allowance is an authorization to emit a specific quantity (e.g., one ton) of pollution for a single year. Each source must develop a compliance strategy to reduce emissions and, at the end of the compliance period, surrender sufficient allowances to compensate for its actual emissions. The cap-and-trade program does not include specific control requirements (e.g., mandatory pollution controls) for individual sources. Instead, sources are offered the flexibility to adopt the most cost-effective solutions to achieve the overall emission cap.

Cap and trade programs work best in situations where:

- Aggregate emission impacts are the principle concern;
- Costs differ across a range of emission reduction options;
- Emissions can be measured accurately; and
- Strong regulatory institutions and contract laws exist.

For more information on cap and trade programs please visit www.epa.gov/captrade.

Simulation Scenario

In the simulation you are an environmental compliance officer assigned to an electric power plant located in the country of Ecoland. You can choose from one of two cap-and-trade scenarios: 1) a program to reduce sulfur dioxide (SO₂) emissions that contribute to acid rain and fine particle pollution; or 2) a program to reduce carbon dioxide (CO₂) emissions that contribute to climate change.

Objective

The senior management at your company has asked you to develop and implement a compliance strategy for the cap-and-trade program. You have the flexibility to switch fuels, install emission controls, shift electricity generation between generating units, add new generating units, initiate demand-side electricity conservation programs, and/or purchase emission allowances from other facilities. The CO₂ program also offers options to invest in emission offset projects, which, if approved by the Offset Review Committee, provide emission offsets that can be used for compliance similar to emission allowances.

Rules/obligations

The rules for the program are very simple, you must:

1. Meet customers' demand for electricity by producing sufficient electricity;
2. Report all allowance transfers to Ecoland's government; and
3. Possess at least one allowance (or offset) for each ton of SO₂ or CO₂ emitted during the compliance period.

If you do not hold sufficient allowances to cover your facility's emissions, automatic noncompliance penalties will be applied for each excess ton of emissions. The automatic penalties include a financial and allowance penalty for each ton. The allowance penalty will reduce your next allocation by the tons of excess emissions from the current compliance period. The purpose of the allowance penalty is to ensure the environmental integrity of the emission cap. The financial penalty is also applied to each excess ton of emissions. Details about the penalty are displayed in the opening **Events** window that is displayed after you select the type of cap-and-trade program from the **Opening Selections** window. Similarly, if you do not generate sufficient electricity to meet demand, your facility's profitability will be lowered to reflect the cost of purchasing electricity from suppliers to meet demand. At the end of each period you will receive a score based on your power plant's performance.

How to Play the Simulation

Start

You will be presented with the **Opening Selections** window (see Figure 1) at the start of the simulation.



Figure 1: Opening Selections window

The facilitator will provide you with the name of your power plant, the type of program (CO₂ or SO₂), and the level of play (beginner or advanced) at the beginning of the simulation (see Table 1). You can make the selections in the **Opening Selections** window and, when instructed by the facilitator, click the **Start** button.

Table 1: Game-play Levels

	Electricity demand	Allowance allocations	Fuel prices	Emission control prices	Offset project approvals	Financial details	News events
Beginner	Constant	Declining	Constant	Constant	Not required	No	No
Advanced	Variable	Declining	Variable	Variable	Required	Yes	Yes

The simulation will display a "snapshot" of your facility (see Figure 2) at the start of the game. The **Facility Information** window contains all of the information about your facility's units, transactions (i.e., allowances allocated, bought, sold, or retired), efficiency projects, and offsets programs (only available for CO₂). The **Summary** section of the **Facility Information** window provides an overview of your compliance and performance status. The objective of the simulation is to hold sufficient allowances (and offsets) to compensate for total emissions and meet consumers' demand for electricity at the lowest possible cost.

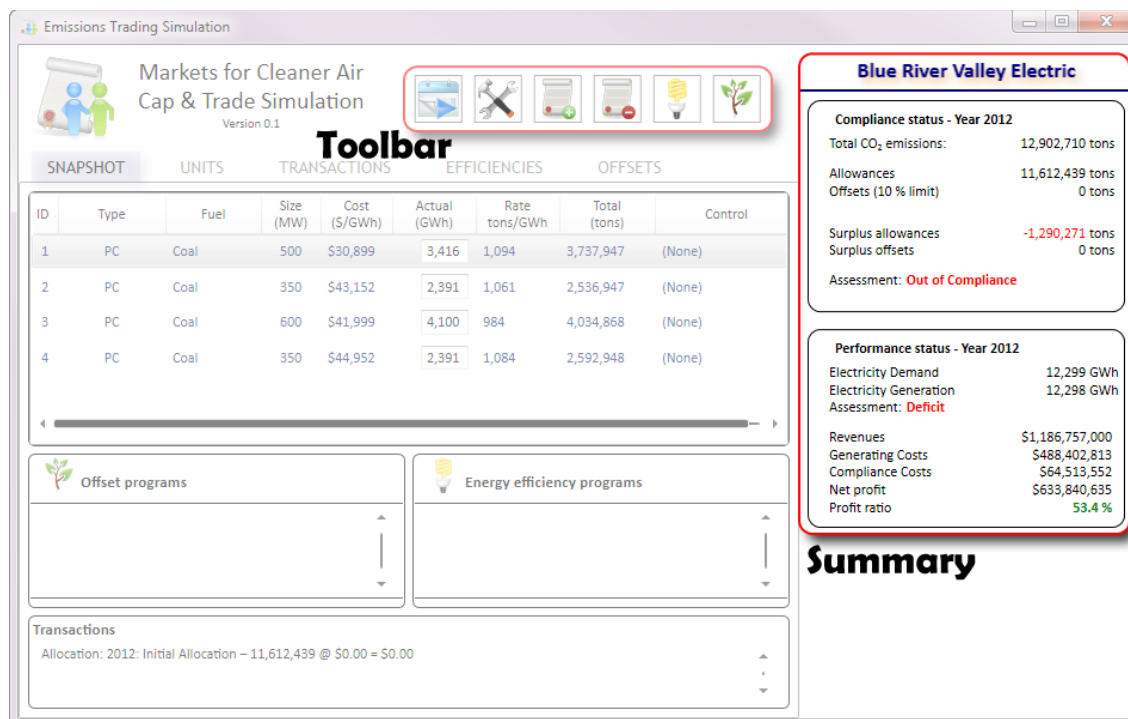








Figure 2: Facility Information window



You can see a breakdown of cost numbers identified with a small triangle. When you pause your cursor over the small triangle, the simulation presents a small window with detailed costs. For example, generating costs are broken into capital payments, operation and maintenance costs, variable (fuel) costs, and total production costs.

You can access key actions in the simulation using the toolbar at the top of the **Facility Information** window (see Table 2).

Table 2: The Toolbar

Icon	Description
 Next period	View a summary of the Compliance and Performance status for the current period and advance to the next compliance period. If you are not in compliance before moving to the next period, automatic penalties will be applied for each excess ton of emissions.
 Install a new unit	Add any of the units listed in the viewing panel, including new coal-, gas-, solar-, or wind-powered units.
 Purchase allowances or offsets	<p>Register allowance or offset purchases from another team at a price and quantity agreed to by the buyer and seller. The result of the purchase will appear in the Transactions window and Summary section (i.e., allowances and compliance costs).</p> <p>Any surplus allowances may be saved for future use.</p>
 Sell allowances or offsets	Register allowance or offset sales to another team at a price and quantity agreed to by the buyer and seller. The result of the sale will appear in the Transactions window and Summary section (i.e., allowances and compliance costs).
 Invest in efficiency project	Invest in demand-side electricity conservation programs to reduce customer demand, thereby reducing the amount of electricity that must be generated in a given period. Several types of efficiency projects are available. Each requires a different investment and provides a specific range of reduction (%) in electricity demand. The result of the efficiency project will appear in the Efficiency window and Summary section (i.e., electricity demand and compliance costs).
 Invest in offset project	<p><i>Available in the CO₂ trading game only.</i></p> <p>Invest in emission reduction projects outside the electricity sector to reduce emissions, and use the reductions to offset emissions. In advanced game-play, the Offset Review Committee must approve projects before any offset credits are issued. Unapproved projects will not be entitled to receive offset credits.</p> <p>Offsets are generated only during the period of investment. The government may establish a limit on the number of offsets that may be used for compliance. Any surplus offsets may be saved for future use or sold.</p>

Reducing emissions at your facility

At the start of the first period you will develop a compliance strategy for meeting the emission reduction requirements. The goal of the exercise is to reduce overall emissions from your facility at the lowest overall cost. You can make reductions by tailoring an emission reduction strategy to the specific characteristics of each generating unit at your plant. You may want to compare the costs per ton of emissions reduced under the different available options and then begin by investing in the least-cost options. If another power plant can make less expensive reductions, you may want to consider buying

their surplus allowances or offsets because it will allow you to meet your compliance requirements at a lower cost. Similarly, if another power plant has higher costs to comply, you may want to consider over complying at your facility and selling some of the surplus allowances. This will increase your revenues (offsetting part of the emission reduction costs). If you have surplus allowances or offsets, these can be banked (i.e., saved) for use in future compliance periods.

Shifting electricity generation between electric generating units

You can shift generation between units by controlling the output of a specific unit (see Figure 3).

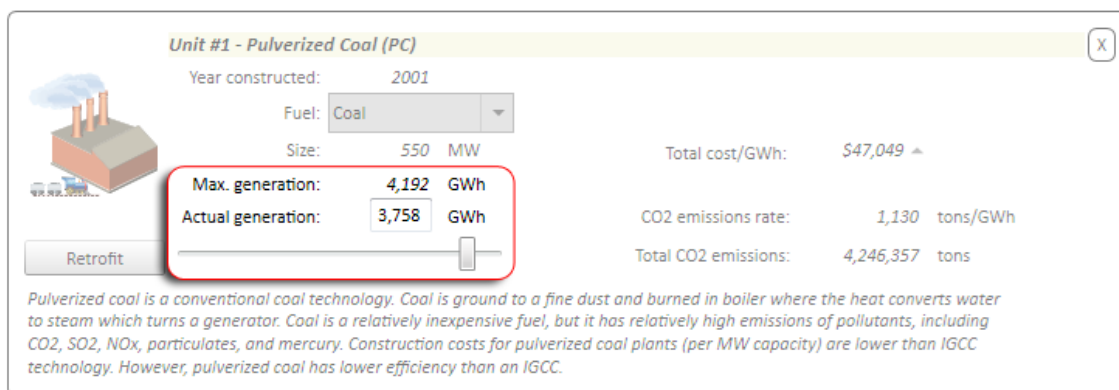


Figure 3: Change generation levels at an electric generating unit

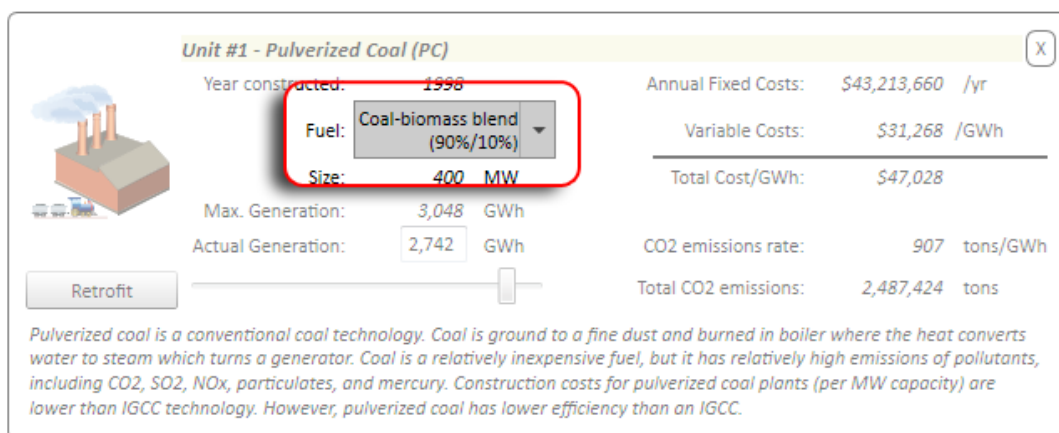
You can control the output of a unit by typing the generation (GWh) in the **Actual generation** textbox, dragging the **Generation** bar left or right, or clicking to the left or right of the **Generation** bar.



Shifting generation to more-efficient, lower-emitting units from less-efficient, higher-emitting units may be among the most cost-effective emission reduction strategies available at your power plant.

Switching Fuels

You can switch fuels to reduce sulfur or carbon content. To change fuels, select a new fuel option in the **Fuel** drop-down list (see Figure 4). This may affect both emissions and variable costs.



Unit #1 - Pulverized Coal (PC) [X]

Year constructed: 1998

Fuel: **Coal-biomass blend (90%/10%)**

Size: 400 MW

Max. Generation: 3,048 GWh

Actual Generation: 2,742 GWh

Annual Fixed Costs: \$43,213,660 /yr

Variable Costs: \$31,268 /GWh

Total Cost/GWh: \$47,028

CO2 emissions rate: 907 tons/GWh

Total CO2 emissions: 2,487,424 tons

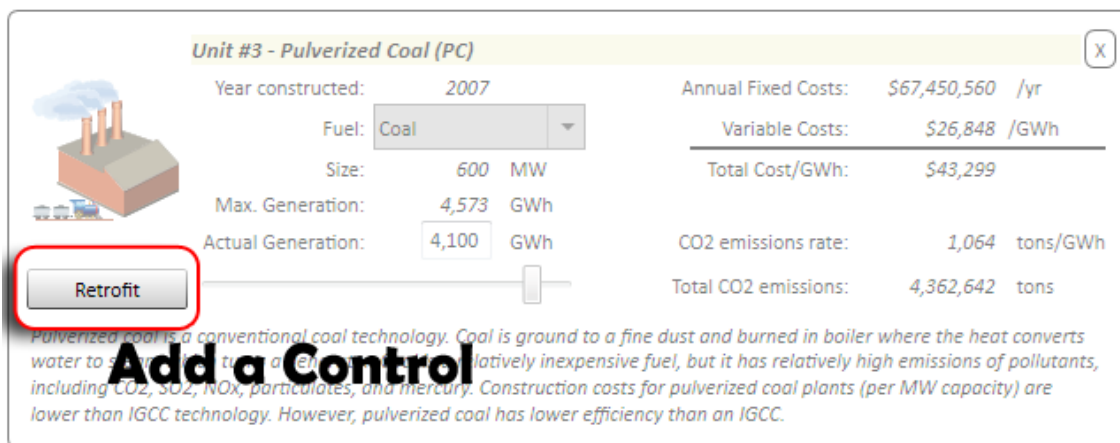
Retrofit

Pulverized coal is a conventional coal technology. Coal is ground to a fine dust and burned in boiler where the heat converts water to steam which turns a generator. Coal is a relatively inexpensive fuel, but it has relatively high emissions of pollutants, including CO₂, SO₂, NO_x, particulates, and mercury. Construction costs for pulverized coal plants (per MW capacity) are lower than IGCC technology. However, pulverized coal has lower efficiency than an IGCC.

Figure 4: Change Fuels

Adding pollution controls

Coal and natural gas units may be retrofitted with air pollution control devices to reduce emissions. Units that do not produce emissions (e.g., wind turbines) do not have available retrofit technologies. To add a control, click the **Retrofit** button (see Figure 5) and review the available controls in the **Retrofit Control** window (see Figure 6). Adding an air pollution control device will increase the capital as well as the operating and maintenance costs. It may also affect the maximum electric generating capacity of the unit because the control may require significant power to operate. The **Retrofit Control** window displays the additional costs of the control, its impact on emissions, and the cost to reduce each ton of emissions. When you click the **Retrofit** button in the **Retrofit Control** window you will be asked to confirm the installation of the control. It is important to note that once you install the control it cannot be removed.



Unit #3 - Pulverized Coal (PC) [X]

Year constructed: 2007

Fuel: Coal

Size: 600 MW

Max. Generation: 4,573 GWh

Actual Generation: 4,100 GWh

Annual Fixed Costs: \$67,450,560 /yr

Variable Costs: \$26,848 /GWh

Total Cost/GWh: \$43,299

CO2 emissions rate: 1,064 tons/GWh

Total CO2 emissions: 4,362,642 tons

Retrofit

Add a Control

Pulverized coal is a conventional coal technology. Coal is ground to a fine dust and burned in boiler where the heat converts water to steam which turns a generator. Coal is a relatively inexpensive fuel, but it has relatively high emissions of pollutants, including CO₂, SO₂, NO_x, particulates, and mercury. Construction costs for pulverized coal plants (per MW capacity) are lower than IGCC technology. However, pulverized coal has lower efficiency than an IGCC.

Figure 5: Retrofitting an electric generating unit

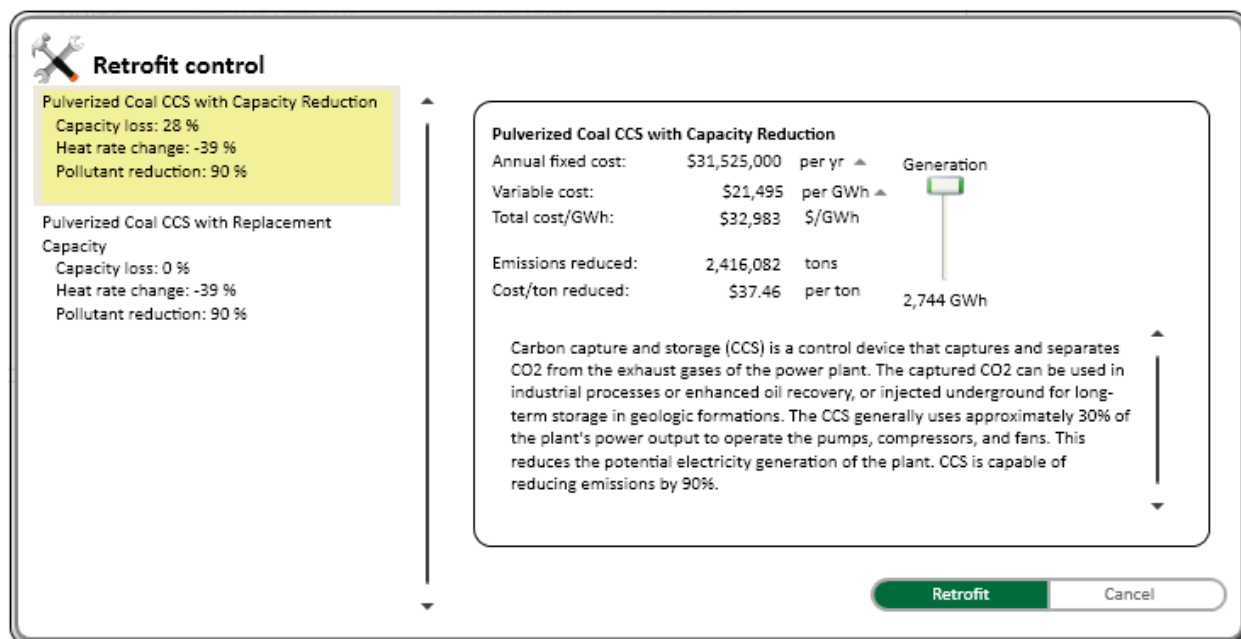


Figure 6: Selecting an air pollution control technology

Adding new electric generating units

Installing a new unit that produces fewer tons of emissions per GWh can help reduce emissions and/or allow you to produce more electricity. There are many options available, including traditional fossil fuel generating technologies such as coal- or gas-fired plants as well as renewable energy sources. These units can be found by selecting the **Install a new unit** button in the toolbar. The **Add Unit** window (see Figure 7) displays the available electric generating units and each unit's costs, capacity, emissions, and the average cost per ton of emissions reduced. The cost per ton is the difference between the new unit's emission rate and the average emission rate of your existing units (i.e., if you add the new unit and proportionally reduce generation from your existing electric generating units, how much will it cost for each ton reduced.) For renewable energy sources, the window indicates the regional resources – level of direct sunlight or sustained winds. In general, the greater a region's resources, the lower the cost will be to generate each GWh of electricity from a renewable technology that makes use of the available resources. More information about the different regions is available in the *About Ecoland* section below.

When you click the **Install** button you will be asked to confirm the installation of the new unit. It is important to note that once you install the new unit it cannot be removed. After you install the new unit, you may want to reduce generation at one or more existing electric generating units (see the *Shifting electricity generation between electric generating units* section above).

Add a unit

Pulverized Coal (PC)
 Nameplate capacity: 500 MW
 Max. generation: 3,811 GWh
 Total variable cost: \$59,455/GWh

Integrated Gasification Combined Cycle (IGCC)
 Nameplate capacity: 500 MW
 Max. generation: 3,416 GWh
 Total variable cost: \$62,512/GWh

Gas-fired Combined Cycle Unit (NGCC)
 Nameplate capacity: 500 MW
 Max. generation: 3,898 GWh
 Total variable cost: \$56,600/GWh

Solar Photovoltaic (PV) array
 Nameplate capacity: 100 MW
 Max. generation: 268 GWh
 Total variable cost: \$134,244/GWh

Solar Thermal
 Nameplate capacity: 300 MW

Pulverized Coal (PC)
 Fuel: Coal
 Size: 500 MW
 Regional resources:
 Maximum generation: 3,811 GWh
 Annual fixed costs: \$78,603,750 per yr
 Variable costs: \$38,830 per GWh
 Total \$/GWh: \$59,455/GWh
 Emissions rate: 958 tons/GWh
 Emissions: 3,649,696 tons
 Avg cost/ton reduced (substitution): N/A

3,811 GWh

Pulverized coal is a conventional coal technology. Coal is ground to a fine dust and burned in boiler where the heat converts water to steam which turns a generator. Coal is a relatively inexpensive fuel, but it has relatively high emissions of pollutants, including CO₂, SO₂, NO_x, particulates, and mercury. Construction costs for pulverized coal plants (per MW capacity) are lower than IGCC technology. However, pulverized

Install **Cancel**

Figure 7: Selecting a new electric generating unit



Amortized/annualized fixed costs are applied to each unit even if a unit does not generate any electricity. Thus, an old coal unit (or any other unit/control) that is no longer generating electricity may still impose a (fixed) cost.

Reducing electricity demand through energy efficiency projects

You can lower electricity demand by investing in energy efficiency programs. The cost of an energy efficiency project as well as the demand reduction varies depending on the project's size and scope. As you invest in energy efficiency projects, you generally take advantage of easier, lower-cost efficiency upgrades first. As a result, future projects are more expensive and yield lower reductions in electricity demand.

Selecting the **Efficiencies** tab in the **Facility Information** window allows you to view the details of the efficiency projects you already implemented, including period, type, demand reduction, cost, and average cost per ton of emissions reduced. The costs of the projects are included in the compliance costs listed in the performance status in the **Summary** section of the **Facility Information** window.



Energy efficiency projects only reduce electricity demand. In order to reduce emissions you will have to reduce electricity generation at one of more of your generating units. If your goal is to lower emissions, you may want to focus on reducing electricity generation from your highest-emitting generating units first.

Reducing emissions outside the electricity sector with offset projects

This option is only available in the CO₂ simulation. Investing in an offset project gives you the option to reduce emissions outside your facility and generate emission offsets that can be used to compensate for emissions at your facility. In advanced game-play, each project must be approved by the Offset Review Committee before offsets are issued. The **Offset Project** window displays the expected range of costs, offsets generated (if approved), cost per offset, chance of approval by the Offset Review Committee, and the portion of the project cost attributable to project design and development (see Figure 8). If a project is rejected by the Committee, you must pay the project design and development costs (i.e., the “development cost portion” percentage multiplied by the total expected project cost) but you will not receive any offsets. If a project is approved, the offsets can be used for compliance or sold to other power plants.

As with the energy efficiency projects, you generally invest in the easier, lower-cost projects first. As a result, future offset projects are more expensive, yield fewer emission reductions, and, in advanced game-play, have a greater risk of being denied by the Offset Review Committee (i.e., the approval rate declines). Although offset projects are often relatively inexpensive reductions, it is important to factor in the risk that you will pay for the project proposal and receive no offsets in return. It is also important to note that some cap-and-trade programs place restrictions on the amount of offsets that can be used for compliance. This information can be found in the **Summary** section of the **Facility Information** window (see Figure 2).

Add an offset project

Landfill Gas Capture
Cost: \$4,465,125 to \$4,688,381
Offsets: 360,000 to 375,000

Manure Management
Cost: \$1,197,450 to \$1,217,700
Offsets: 160,000 to 173,000

Coal Mine Methane Recovery and Utilization
Cost: \$12,825,000 to \$13,432,500
Offsets: 950,000 to 1,080,000

	Minimum	Maximum
Cost range	\$12,825,000	\$13,432,500
Number of offsets	950,000 tons	1,080,000 tons
Cost/ton offset	\$11.88	\$14.14
Chance for approval	50 %	
Development cost portion	8 %	

Coal mines can have high levels of methane gas, a potent greenhouse gas, that is released during mining activity. Methane gas is an explosive gas that poses a hazard to coal mine safety. The methane gas can be collected and used to fuel the mines, power plants, manufacturing facilities, and even homes.

Invest **Cancel**

Figure 8: Investing in an emission offset project



The cost/ton value can help you identify your lowest cost options for reducing emissions. Therefore, it is important to know how this value is calculated. For emission controls and offset projects there is a fixed cost per ton of emissions reduced. New units and efficiency projects displace or reduce generation at existing units which you will select. For new units and efficiency projects, the cost/ton is the weighted average emission rate across your facility's existing generating units and the cost of the project. Because it is an average, it is possible the actual cost/ton will be higher or lower than the average shown on the screen.

Selecting the **Offsets** tab in the **Facility Information** window allows you to view the investment, cost, offset quantity, and approval status of each offset project you implemented. The cost of the projects is included in the compliance costs listed in the performance status in the **Summary** section of the **Facility Information** window.

Trading emission allowances and offsets

You may opt to buy or sell allowances or offsets with another power plant. After negotiating the transaction with the other facility, both the buyer and seller must enter details of the transaction into the simulation.

Buying and selling allowances is tracked in the **Transactions** window. The result of all allowance trades is also listed in the **Summary** section of the **Facility Information** window (see Figure 2). Each transaction may also alter your profit ratio, surplus allowances/offsets, and compliance cost.

Blue River Valley E

Compliance status - Year 2015
Total CO₂ emissions:

TRANSACTIONS EFFICIENCIES OFFSETS

Allowance/Offset Purchase

Transaction Type
☒ Allowances ☐ Offsets

Team
Red Butte Power

Quantity: 0

Price: 0

Allowance/Offset Sale

Transaction Type
☒ Allowances ☐ Offsets

Team
Red Butte Power

Quantity: 0

Price: 0

Compliance costs
Net profit
Profit ratio

Major fire shuts down plant for year

Figure 9: Trading allowances

Selling

If you have a surplus of allowances or offsets, you can sell them or save them for future use. The added revenue can help you invest in control technologies, more efficient electric generating unit(s), or energy efficiency program(s). Before selling allowances, you must determine how many allowances you want to sell and what minimum price you will accept. You may then ask other participants if they want to purchase your allowances or, if there is a broker, you may tell the broker that you are willing to sell allowances at a specific price. After you or the broker has negotiated a trade, you may be asked to report the allowance transfer to the facilitator. Enter the trade into the simulation program by clicking on the **Sell allowances or offsets** button in the toolbar. Select whether you have sold allowances or offsets and the name of the buyer, then enter the quantity and price per allowance or offset.

Buying

If you need additional allowances to cover your emissions or would like to position yourself for future uncertainties, you can buy allowances or offsets. Before buying allowances, you must determine how many allowances you want to buy and the maximum price you are willing to pay. You may then ask other participants, or the broker, if they are willing to sell allowances. After you or the broker has negotiated the purchase, you may be asked to report the allowance transfer to the facilitator. Enter the trade into the simulation program by clicking on the **Purchase allowances or offsets** button in the toolbar. Select whether you have purchased allowances or offsets and the name of the seller, then enter the quantity and price per allowance or offset.

You must enter any final transactions when the facilitator tells you it is time to begin the next compliance period. Completed transactions will be displayed in the **Transaction** tab on the **Facility Information** window. You can review past transactions at any time by selecting the **Transaction** tab (see Figure 10).

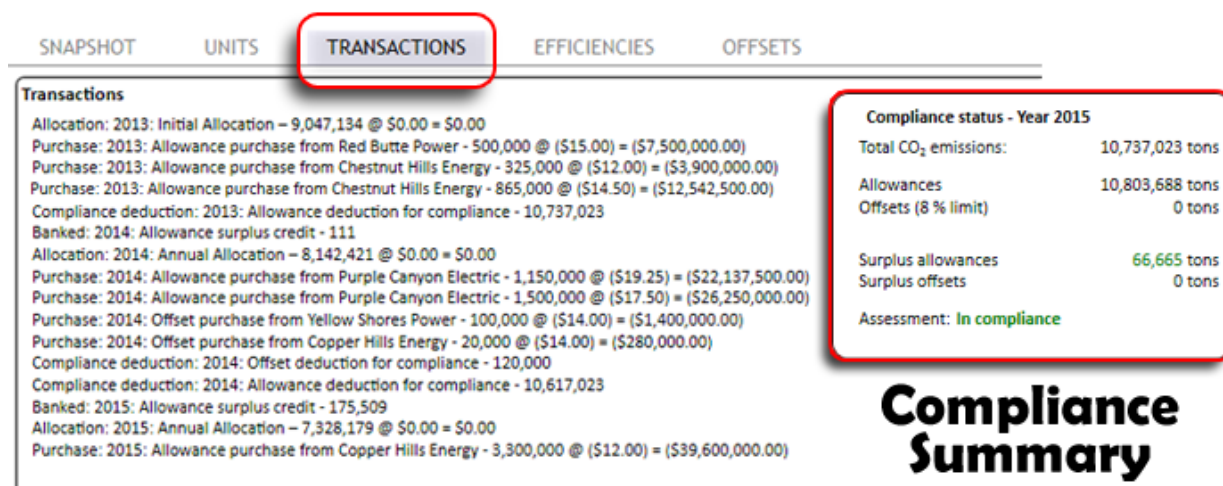


Figure 10: List of allowance and offset transactions

*Note: Price and Quantity in Figure 10 are hypothetical and do not reflect actual game-play.



It is important to keep track of the costs of your emission reduction options. In general, you should try to sell allowances at a cost greater than your cost to reduce emissions and buy allowances at a cost equal to or less than the cost to make further reductions.

Adjusting strategies to accommodate unplanned events

In advanced game-play, unplanned events may occur between periods, resulting in higher or lower electricity demand, costs for control technologies, or costs for fuels. These events may be permanent (e.g., a major employer moves into your region) or temporary (e.g., due to high demand, steel prices increase). You may decide to adjust your compliance strategy based on changes in demand or fluctuating costs. These events are automatically generated as you progress through the simulation. Each time when you advance to the next compliance period the simulation will display a summary of all the events for the next compliance period. The event summaries are also displayed in the **Events** section of the **Facility Information** window. Clicking on an event listed in the **Events** section will display more detailed information about the event.



If the price of a certain commodity increases temporarily due to an event, you may want to consider ways to work around the increase. For example, if steel prices rise in a certain year, it may be cheaper to delay construction of new air pollution control technologies.

Viewing results and advancing to the next compliance period

When the facilitator informs you that it is time to move to the next period you should be certain that you have enough allowances to cover your emissions and that you are producing enough electricity to meet demand. After verifying that you are in compliance and producing enough electricity you should click the **Next period** button in the toolbar. You will then be shown an **End-of-year Summary** window with the results for the period and, after you confirm that you wish to advance, your score for the period. Once you advance to the next period you cannot go back to a previous period.

The score represents the environmental and economic performance of your power plant. It is based on the following criteria:

- Complying with the allowance/offset holding requirements
- Holding excess allowances or offsets (these are assets with economic value)
- Meeting demand for electricity

- Remaining profitable
- Minimizing compliance costs

You may be asked to report your score to the facilitator. When you are instructed, click the **Done** button on the **End-of-year Summary** window. If you need to redisplay the **End-of-year Summary** window, you can click the name of your power plant in the upper right corner of the **Facility Information** window.

Frequently Asked Questions

1. Do offset projects continue to provide offsets in future years?

No. In the simulation, if your project is approved you receive a one-time allocation of offsets. You may continue to invest in additional projects during the current and future periods.

2. What happens if an offset project is not approved?

If an offset project is not approved you will not receive any offsets and will be required to pay for the offset project preparation and review costs. These costs are displayed in the offset project details that you can review before deciding whether to invest or not. They are calculated as a percentage of the total project cost.

3. How are the power companies' fleets determined?

Model units are randomly assigned to the different power companies at the start of simulation. Note that emission allowance allocations are based on the size and type of generating units assigned to the power company.

4. Why are my costs for a new unit different from another participant?

Regional resources and fuel costs vary. Some regions have greater wind potential making wind power cheaper, while others have greater solar intensity making solar power cheaper. Also, some regions require higher transportation costs which affect the cost of coal or gas.

5. When should I advance to the next period?

You should only advance to the next period when instructed to do so by the facilitator.

6. Who enters a transaction in the simulation, the buyer or the seller?

Both parties must enter the transaction in their instance of the simulation. The facilitator may also enter the transaction in the Registry Application.

7. If I install a control can I uninstall it?

No. Once controls are installed they cannot be uninstalled and you will have to continue paying for the control technology even if the unit with the control technology is no longer generating electricity.

8. Why did my investment in energy efficiency not reduce emissions?

Energy efficiency projects do not provide emission reductions by themselves. These projects can reduce demand which allows you to generate less electricity. Generation must be decreased if you want to realize emission reductions. Note that decreasing generation at units with the highest emissions rate will realize the largest emission reductions.

About Ecoland

The country of Ecoland has five distinct regions – Central Highlands, Fertile Plains, Coastal Ridge, Southern Forests, and Desert Valley. Each region has unique characteristics with different potential (and costs) for each fuel type. The map below identifies the power plants in each region and the level of regional resources for each fuel type.

